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its life-history may be taken to represent one extreme in the development of such behavior among molluscs, seen perhaps in its highest condition in *Octopus* (cf., e.g., Cowdry, 1911).

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#### AN F<sub>1</sub> SPECIES CROSS BETWEEN HORDEUM VULGARE AND HORDEUM MURANIUM

WITHIN the last few years the subject of species hybridization has increasingly occupied the attention of those interested in the subject of heredity. The possibility of the genetic analysis of species hybrids depends upon the ability to cross and to secure offspring from the species in question. During the course of a plant-breeding investigation which was commenced at the

University of California, an attempt was made to determine if the common cultivated barley could be crossed with wild species of *Hordeum*. The wild species which were used were *H. nodosum* and *H. murarium*. For the sake of convenience the system of nomenclature proposed by H. V. Harlan (1918) will be adopted for the common varieties of barley used in the investigation.

One of the crosses which was attempted was between *H. vulgare vulgare pallidum* and *H. nodosum*. This cross was an entire failure, however, as no seeds were obtained from any of the flowers which were crossed. The anthers of the male parent were fully mature, and the plant which was used for the female parent was perfectly healthy and normal when the cross was attempted. As a matter of fact a successful cross was made the same day between a different head of the same plant of *H. vulgare vulgare pallidum* and *H. vulgare distichon palmella*. At the present time it would be difficult to say whether the absolute failure of this particular cross was due to the incompatibility of the gametes of the two parents or to certain errors of technique.

The other cross which was attempted was between *H. vulgare trifurcatum typica* and *H. murarium*. The contrast between the two parents was very marked and distinct. The low and often recumbent habit of growth of *murarium* was contrasted with the relatively tall and erect habit of *vulgare*. The light green leaves and stems of *murarium* were not nearly as stout as the gray green leaves and stems of *vulgare*. The spikes of the two species are also quite distinct. The spikes of *murarium* are compressed and composed of a number of rather narrow elongated spikelets which form rather a loose head. The spikes of *vulgare*, on the other hand, are generally composed of a number of relatively short and wide spikelets. Both species are annuals, but without going into further detail it is evident that there are a large number of morphological differences between these two species.

From the second cross two viable hybrid seeds were obtained. These grains resembled the typical seeds of the maternal variety in every respect. When they were planted, however, it required one and three days longer for the seed to germinate than for self-fertilized seed of the female parent.

The F<sub>1</sub> seedlings differed markedly from plants of *H. vulgare* in the same stage of development. The sheath or coleoptile had a greater circumference than the blade, thus fitting loosely

around it instead of adhering closely to the blade as in *vulgare*. The sheath was closed along the side and open only at the apex. The blade of the first leaf was narrow, linear and spirally twisted with slightly roughened edges. The blade was about one twelfth of an inch in width and tapered slightly toward the apex (Fig. 1).

One plant grew to a height of four inches and developed roots two to three inches long (see Fig. 2). The other plant developed somewhat more slowly, reaching a height of two inches

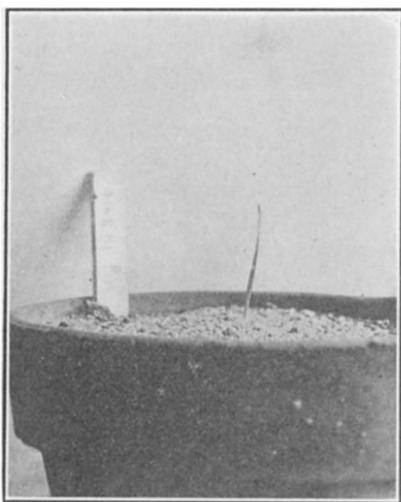


FIG. 1. A first generation hybrid between *Hordeum vulgare trifurcatum typica* and *Hordeum murarium*.

with roots of the same length. At this stage the plants ceased development and gradually started to wither. Only one blade was present and this extended to the seed. There was no evidence of any nodes being formed.

Due to a change of residence the writer has not been able to continue the investigation for a short time, but it is hoped that this cross may be subjected to further breeding tests as well as a histological examination. The theoretical hypotheses concerning species crosses have been thoroughly reviewed by other writers (Babcock and Clausen 1918), but it may not be out of place to briefly state the particular theories which probably account for the results considered in this paper.

It has already been pointed out that *H. vulgare* and *H. murarium* differ in a large number of morphological characters.

*H. murarium* may be considered as a monotypic species, and the slight variations which are found in the species are undoubtedly due to the effects of the environment and would be classed as non-heritable variations. *H. vulgare*, on the other hand, is a polytypic species consisting of many varieties which differ in a number of morphological characters. Most of the factors which condition the characters of *vulgare* display har-



FIG. 2. F<sub>1</sub> species hybrids between *Hordeum vulgare* and *Hordeum murarium* at the stage of growth at which development ceased.

monious interrelations with one another and mendelize in a normal fashion. Several factors involving chlorophyll reduction have been discovered, however, and these genes have been found to be incompatible with the normal functioning of the chromatin system. In these cases after the food material in the seed has been exhausted the seedlings usually die, for the change

in the factors has been too far reaching to give a normal functioning reaction system.

This brings forth the theory of reaction systems which has been thoroughly reviewed by Goodspeed and Clausen (1917a). The purpose of the discussion in the preceding paragraph was to show that both *vulgare* and *muranium* possess a normal reaction system, and second that a normal reaction system may sometimes be disturbed by lethal factors. When we attempt to combine two distinct reaction systems, however (and the distinct morphological characters of the two species as well as the breeding test would indicate that the two species possessed different reaction systems) an inharmonious group is often formed which fails to function in a normal fashion. In the case of chlorophyll reduction there is one or at most only a few factors disturbing the reaction system. In the case of species crosses there are a number of factors, which in all probability differ qualitatively, coming from two distinct reaction systems and these often fail to harmonize. The results are often similar, however, for the differences between the reaction systems of *vulgare* and *muranium* are so profound that the resulting system is not able to function after the food material in the seed is exhausted.

The type of species cross described in this paper is quite similar to the species cross between *Crepis capillaris* and *Crepis tectorum* recently described by Babcock and Collins, 1920. The two species of *Crepis*, besides differing in several morphological characters, were found to differ in chromosome number. Reciprocal crosses gave equivalent results, or the dominance of *tectorum* cotyledon characters in  $F_1$  accompanied by hybrid vigor. The  $F_1$  seedlings died, however, in every case at the end of the cotyledon stage. Cytological examination revealed a complete lack of order in the cell systems, and as a result these systems failed to function and development ceased. The species cross in barley involves slightly greater contrasts perhaps than those in *Crepis* but both give nearly parallel results.

There are, as has been pointed out by others, all degrees of incompatibility of reaction systems in species crosses. The range of compatibility includes cases of complete or nearly complete fertility, as in the species crosses in *Antirrhinum* (Baur and Lotsy), examples like those found in *Nicotiana* (Goodspeed and Clausen 1917b) where the fact of incompatibility does not become evident until the fertilization of the  $F_1$  plants, and

finally we have species which exhibit complete incompatibility by refusing to cross with one another. The range includes many intermediate conditions like those found in *Crepis*, which nearly approach complete incompatibility. The cross between *H. vulgare* and *H. murarium*, then, is well down the scale and can be grouped in the class with the two species of *Crepis* as showing nearly complete incompatibility.

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#### A NOTE ON UNILATERAL REACTIONS OF THE MELANOPHORES OF THE HEAD IN FISHES

IN most discussions of the physiology of the chromatophores of fishes it is apparently assumed that the reactions are strictly bilateral, *i.e.*, synchronous on the two sides. The writer, however, has lately observed a number of cases in which the reaction was either unilateral or imperfectly bilateral.

Upon death, the melanophores of one side of the head in some cases become all "contracted" to the extreme, while those of the other side become widely "expanded." As a result, one side of the head becomes very pale, the other side blackish, the two areas being abruptly opposed along the mediadorsal line. This notable